From flying rockets to Tesla: examining the sustainable mobility preferences of primary school children in Denmark and the Netherlands

Article (Accepted Version)

From Flying Cars to Tesla: Examining the Personal Automobile Preferences of Primary Schoolchildren in Denmark and the Netherlands

1 Introduction

Worldwide, the transportation sector remains significantly dependent on fossil fuels, with an array of sobering, and growing, negative environmental and social impacts frequently discussed in the literature. To decarbonize this sector in part, the International Energy Agency suggests that plug-in electric vehicles must make up at least 40% of new vehicle sales globally by 2040 to be on track to stabilize greenhouse gas concentrations at 450 ppm (IEA, 2015). The International Renewable Energy Agency (IRENA) reports in their most recent outlook that between 2015 and 2050, the number of electric vehicles (EVs) needs to jump from almost one million to one billion cars (more precisely from 1.24 million passenger cars to 965 million passenger cars); from 200,000 electric buses and trucks to 57 million; and from 200 million electric scooters and bikes to 2.16 billion (IRENA, 2018). Others similarly argue that a diffusion of EVs and other innovations in technology and behaviour—biofuel, hydrogen, automation, ridesharing, bicycling—is urgently needed to meet carbon targets (Figueres et al., 2017; Geels et al., 2017; Jacobson, 2009; Pacala and Socolow, 2004; Williams et al., 2012). Yet, the acceptance and adoption of these innovations remains uncertain—and to a large degree contested (Axsen and Sovacool, 2019).

One low-carbon innovation in particular, electric vehicles (EVs), offers a range of benefits for transport, climate change and local urban health environments. Pending type, model and age, EVs reduce overall energy consumption through a higher energy efficiency, emit no tailpipe emissions, are open to a wider variety of renewable energy sources, have the potential to stabilize the electricity grids, and are more comfortable and cheaper to drive (Buekers et al., 2014; Sioshansi and Denholm, 2009; Sovacool and Hirsh, 2009). Recent studies further indicate that EV adopters start to adapt other aspects of their life towards more sustainable routines (Ryghaug and Toftaker, 2014). It is therefore fortunate that after years of small models and a lack of standardization across industry, sales are picking up and more car companies and governments are publicly shifting from fossil fuel technology to electric power trains (IEA, 2017).

Unfortunately, in its current state the business case behind electric mobility remains hindered by high costs (even though battery prices are coming down), the range of car models (also increasing yearly), the need for recharging infrastructure (which needs demand from EVs to be viable), and the uncertainty about other technologies (biofuels, hydrogen, combustion engine developments) (Kester et al., 2018). Furthermore, there are concerns about the rebound effects of EVs (Greening et al., 2000; Isenhour, 2010): that those driving alternatively fuelled vehicles rationalize that they can drive more, an effect found in the UK (Graham-Rowe et al., 2012), Sweden (Langbroek et al., 2018) and Austria (Seebauer, 2018). Lastly, these developments are all still relatively recent. Studies show that consumers remain rather unaware of EVs and their benefits, and maintain outdated images about the quality and characteristics of EVs (Egbue and Long, 2012; Rezvani et al., 2015; Sovacool et al., 2017).

As part of the research on consumer awareness and lack of knowledge around (electric) mobility (Axsen et al., 2016, 2013; Liao et al., 2017), this paper studies the personal car preferences, perceptions and EV knowledge of primary schoolchildren aged 9-13. Admittedly, this is a somewhat odd target group as they will not be buying or driving an electric vehicle in the foreseeable future and are therefore ignored by consumer research on private (electrified) automobility and EV adoption research.

However, children are 'metaphorically and literally the drivers of the future (Kopnina, 2011, p. 578).' Furthermore, in their capacity as passengers they are a prime group affected by transport pollution and congestion (Borg et al., 2017). In addition, noting that children still gain and select information from media sources in the absence of, or even against, parental or school messages (Baslington, 2009, p. 315), we would argue that the perception and knowledge of children on electric mobility could act as a proxy and baseline for a broader consumer awareness about EVs in society, precisely because they are not exposed to car purchase and maintenance decisions. As Sovacool et al. (2019, p. 182) write, 'Environmental values, preferences for particular technologies, and patterns of sustainability and natural resource consumption all begin in childhood.' And lastly, we wonder how the current generation of children perceives EVs and personal car transport in general, as more than 20 years ago Leeson et al. (1997a, p. 27) concluded that a strong majority (more than threequarters) of 165 primary schoolchildren in the United Kingdom already knew that electric vehicles reduce emissions. It is that same generation that is now actively supporting the uptake of EVs as younger adults.

Hence, we have conducted a survey among 587 children in the Netherlands and Denmark aged 9 to 13. Specifically, this paper asks two questions: (1) to what extent are children aware and knowledgeable of EVs; and (2) how do children perceive the benefits, disadvantages and future of personal cars?

With these questions, the paper aims to make three contributions. First, it adds to the scant literature on children's perceptions and awareness of EVs and does so, to the best of our knowledge, through a first international comparison. Second, for the EV consumer literature it surveys a difficult to reach and non-traditional group of car users in order to gain insight on minimal EV awareness in society more broadly. Lastly, continuing on earlier informal differentiations between groups of children by Kopnina and Williams (2012), Sigurdardottier et al. (2014), and Sovacool et al. (2019), the paper utilizes a cluster analysis to identify groups of children with different expectations about future personal car use and examines the demographics of these groups and how the future expectations of these groups of children relate to their current perceptions about the most important benefits and disadvantages of cars.

The study's results are promising for a transition to electric vehicles. The sample shows a minimum level of knowledge about EVs, a clear view on the disadvantages of cars and an even clearer view on how to proceed with car-based transport in the near future. Below these questions and the results are taken up after a brief overview of the current literature and a description of the research design. The conclusion summarizes and reflects.

2 Children and cars: a review

With its focus on children aged 9-13, this paper fits a small and slowly growing literature on children at the intersection between transportation and environmental research. In transport studies there is quite some research on children’s mode of transport (Easton and Ferrari, 2015; Helbich et al., 2016; Kaplan et al., 2016; Mitra and Buliung, 2015), yet specific research on children’s car perceptions remains limited to the studies by Boyes and Stanisstreet (1998), Baslington (2009), Kopnina (2011), Kopnina & Williams (2012), Sigurdardottir et al. (2014), Sovacool et al. (2019) and Davison et al. (2003). In contrast to transport studies, the research on children’s environmental awareness and environmental education is quite large and even includes multiple dedicated journals (Balmford et al., 2002; Borg et al., 2017; Leeson et al., 1997a; Payne, 2016). However, only Kopnina (2011) and Egbue et al. (2015) seem to be dealing specifically with electric vehicles in this literature.

That there is little research on how children regard (sustainable) transport, let alone EVs, is a conclusion shared by those few working on it (Baslington, 2009, p. 307; Kopnina, 2011, p. 573). The research that does look specifically at children’s perceptions towards personal cars seems to study either how children of different age groups view different modes of (sustainable) transport or how they view the environment. Methodologically, these studies are characterized by a limit to specific local regions and a struggle to find methods that allow for the different cognitive capacity of the various age groups. Content wise, studies find that children are positively engaged towards cars (Kopnina, 2011) and have a strong desire to learn to drive (Line et al., 2010), which is attributed to the social status of cars (Kopnina and Williams, 2012; Line et al., 2010; Sigurdardottir et al., 2014) as well as the sociotechnical lock-in and dependency on cars for employment, social engagements, etc. (Baslington, 2009; Urry, 2004).

This might in turn explain the conflicting findings among more environmentally oriented studies, with some studies finding that children are aware of the environmental consequences of personal cars (Batterham et al., 1996; Leeson et al., 1997a) and others concluding that children know very little or hold misconceptions about the impact of cars and environmental sustainability in general (Balmford et al., 2002; Boyes and Stanisstreet, 1997; Egbue et al., 2015).

Many of the studies themselves find mixed results and offer nuanced analysis as to its origin. For example, Davison et al. (2003) concluded, based on a large survey among 12 schools in Scotland, that children are aware of the sustainability issues behind transportation, and that much of the differences depend on the school's input (e.g., environmental programs), the parents' opinions and the extent to which these two 'messages' conflict. Furthermore, they concluded that this environmental awareness does not necessarily result in adjusted behaviour, as many of the children in their sample simultaneously stated that the car would remain an important mode of transport (Davison et al., 2003). Their study further points to the importance of context, age and gender, as they conclude that girls are more prone to environmental concerns, while boys are more aware of the health effects of biking and walking.

Leeson et al. (1997a, 1997b) conducted a large survey among 630 children between 11 to 16 years old in 4 UK schools. For them 'the high profile and media attention given to the environmental impact of vehicle emissions' makes it 'probable that children will have formulated their own ideas and constructs about this issue from out-of-school sources (1997a, p. 90).' Simultaneously, they argue that children 'hold misconceptions' about issues pertaining to the environment, even if they have had official lessons. Their research subsequently confirms that children have an awareness of more practical environmental consequences (traffic jams, air pollution, the benefits of electric propulsion), but struggle with more abstract concepts like climate change and that their sample of children answers faulty on a number of questions pertaining to the environmental impact of tailpipe exhausts – although the depth of these questions makes it interesting to see if adults would have answered differently. Elsewhere, Line et al. (2012) similarly find that children recognize some environmental consequences of cars but not all of them.

As stated earlier, only two articles focus specifically on electric vehicles. Among these, Kopnina (2011) focusses on EVs in a more qualitative study based on 69 writing assignments with children aged 10-11 and 9 follow-up interviews in Amsterdam, the Netherlands. As she finds a 'great variation in both effective states […] and cognitive levels (2011, p. 578)', Kopnina too highlights how the socio-political context and school programs influence the attitude of children. She subsequently argues for more attention to these sources and a need for environmental curricula to include the relationship between transport and the environment (Kopnina, 2011, p. 577; c.f. Boyes and Stanisstreet, 1997).

More recently, Egbue et al. (2015) confirm that knowledge about electric mobility is something that can and should be learned. As they state: 'typically, students and even teachers have no experience about alternative fuel vehicles and as a result, it is not likely to be a topic discussed in class (2015, p. 665).' Subsequently, they put together a one-day curriculum for an introductory science workshop on electric mobility in order to engage 26 American girls in the 7th and 8th grade (13 to 14 years old) – while testing what they knew before and after the workshop.

Together these articles try to bridge research on transport, which focusses on the usage of personal vehicles, the motives for having them and the impact of automobiles on social life, with the research on environmental education, which focuses on changing children's attitudes towards the environment as well as measuring the current environmental knowledge of different age groups. This paper updates these findings with a focus on electric mobility and offers an international comparison between Denmark and the Netherlands, two early movers towards EVs. Importantly, while the above literature is partly driven by the desire to change children's perceptions and behaviour (Line et al., 2012), this paper's prime interest lies in the current state of their EV awareness and knowledge and how this relates to their car perceptions and ideas about the future of personal car-based transportation.

3 Research design

This section briefly introduces the survey, the sampling and survey procedure, as well as the data analyses.

3.1 The survey

To study the preferences, knowledge and expectations of children about personal cars and EVs, the authors developed a short survey of 10 questions (see Appendix A). The survey was distributed to children in the Netherlands (school groups 7 and 8) and Denmark (school groups 4 and 5). This equates to children between 10 and 12 years old, but also includes some 9 and 13-year old's due to group compositions. Importantly, we thus do not use 'pictorial' surveys (Baslington, 2009), show cards (Balmford et al., 2002) or verbal focus groups and interviews (Kopnina, 2011). Following the advice of our experienced co-author, a schoolteacher, we did put strong emphasis on the cognitive level of our sample, mainly by keeping the survey and the survey questions as simple and short as possible. Amongst others, and in line with earlier questions in the literature, we asked about their favourite car, what they thought was most important about cars, what was least important, how much a car and an EV cost, and what future car-based options were most important.

Two other reason to keep the survey simple, besides the cognitive level of the children, are the 'pleasing or satisfying strategy' of children (Borgers et al., 2003) and the 'primacy effect' (Bell, 2007). The pleasing or satisfying strategy (that children answer to please) especially returns in cases with a clear favourable option, like our study on 'new' EVs and how they relate to 'old' internal combustion engine vehicles (ICEVs). We countered this by asking about cars and transport in general and by clearly separating positive and negative aspects. We also asked the children to rank their answers in three of the ten questions. This limits the number of available statistical methods, as the survey loses the strength of association between the choices and because it is unclear whether the children even like their first choice, but it is a relative easily grasped method that forces the children to choose instead of pleasing the authors by answering positively on a Likert scale. Similarly, the primacy effect (that children pick the first things they read) was countered by minimizing suggestive phrasing and by moving the popular answers to the bottom of the ranking questions. Additionally, Bell (2007) highlights the importance of word choice, when describing how something as simple as the difference between a 'school trip' and a 'class trip' can already affect an answer when researchers ask for school trips, but the children read this literally and only go on what they consider class trips. Hence, we did not pre-define EVs, and when asked by children also allowed for the inclusion of hybrids, just as we asked for the cost of a car and EV without specifying the class of car. It was decided not to add triangulation questions to keep the survey as short as possible.,

3.2 Sampling

The sampling was purposeful and convenient as the children were approached through their schools. The initially contacted schools (n=79) were chosen based on previous professional contacts in the Netherlands and the convenience of our base of operations in the respective countries. In both countries the cooperating schools (n=15) are situated in small to medium sized towns or city neighbourhoods across primarily the north of Overijssel and the southeast of Friesland in the Netherlands and the centre of Midtjylland in Denmark (see appendix B); these are all rural or intermediate regions with below average socioeconomic scores (Table 1). The schools were approached at least twice without differentiating between state run and charter schools (privately organized but publicly funded schools), although we excluded special needs education. After a positive response from the director or teacher, a date was set for a personal visit, and, if requested, a letter sent to the parents explaining the research and data requirements (e.g. gender and age). During the visit, the children were handed a translated paper version of the survey and offered a brief, nonspecific introduction about the procedure and background of the study stressing that it was voluntary, that names were not necessary and that the survey was not a school test. The survey taker, a certified teacher, remained available to clarify the survey and answer more specific questions about electric cars after all the children handed in the survey. On average, these visits lasted about 30 minutes per class.

This sampling approach has certain limitations, besides offering a snapshot of stated preferences in a changing context and targeted at respondents who are growing and learning rapidly. First, the sample is clearly not representative for all children in both countries, but the study does offer an attempt to move beyond the urban focus in the studies above and the traditionally white, often older, more highly educated homeowners that permeate EV surveys and choice experiments (Bailey and Axsen, 2015). Another limitation of this approach is that these intermediate regions have fewer public transport opportunities than more urbanized regions, meaning that the children can be assumed to be more car focused.

Additionally, there are several challenges inherent to the international nature of the survey. Language obviously, but also different systems and statistics. For example, the school systems in the Netherlands and Denmark differ. Primary schools in the Netherlands run from the age of 4 to 12, whereas in Denmark they start from the age of 6 until the age of 16 – thus impacting school size numbers. Furthermore, in the Netherlands one teacher teaches all courses to one group, in Denmark one group is thought by multiple specialized teachers – something that impacted the organization of survey appointments. A second problem arose due to the lack of corresponding socioeconomic data of the local regions and municipalities where the survey is taken. With different administrative boundaries and levels of statistics, the paper had to refer back to Eurostat's NUTS 2 regions to confirm that the participating schools indeed are situated in regions with a lower socioeconomic status than the average of the countries (See Table 1, as well as Appendix 2). It should be noted, however, that there are quite some socioeconomic differences between the schools in the Netherlands, and that the Danish schools are all situated in larger well-to-do regional towns that might actually score above the regional average.

Table 1: Income and education levels of school regions versus national average

	Number of schools (and students)	Purchasing power standard based on final consumption per inhabitant, in euros (2014)	Less than primary, primary and lower secondary education (levels 0-2) (2015)	Upper secondary, post-secondary non-tertiary and tertiary education (levels 3-8) (2015)	Tertiary education (levels 5-8) (2015)
Denmark		19,900	19.6	80.4	37.1

Midtjylland	4 (205)	19,100	19.8	80.2	34.6
Netherlands		21,500	23.6	76.4	35.3
Friesland	9 (209)	18,300	25.1	74.9	25.4
Overijssel	1 (71)	19,100	23.1	76.9	31.4
Flevoland	1 (102)	21,000	24.8	75.2	30.0

Source: (EUROSTAT, 2017)

In the end, 587 children completed the survey across 15 schools (see Table 2), with only a handful of incomplete responses that had to be excluded. Of these 587 respondents, 382 came from 11 schools in the Netherlands and 205 from 4 schools in Denmark. While underrepresented in number of schools, Denmark is slightly overrepresented in the sample, as 24.3% of the total number of Dutch and Danish children aged 0 to 14 are Danish, while in our sample the Danish children account for 34.9%. The distribution of charter schools is equal between the countries, with 205 children in both Danish and Dutch privately organized schools, while another 177 children attend state run schools in the Netherlands. Contacted state run schools in Denmark refused or were unable to participate. School size ranged from very small schools with 50 pupils up to schools with 400 or even 645 pupils. Lastly, with 292 girls and 295 boys, the survey is rather well balanced in terms of gender.

Table 2: Demographics of Survey Sample (n = 587)

		Netherlands (n=382)	Denmark (n=205)	Total (n=587)
Gender	Girl	48.7%	51.7%	49.7%
	Boy	51.3%	48.3%	50.3%
Age	9	1.8%	3.4%	2.4%
	10	23.6%	28.3%	25.2%
	11	48.4%	46.8%	47.9%
	12	24.3%	20.5%	23.0%
	13	1.8%	1.0%	1.5%
School Type	Public School	46.3%	0.0%	30.2%
	Charter School	53.7%	100.0%	69.8%
School Size	Small (0 - 125)	31.4%	0.0%	20.4%
	Medium (126 - 250)	23.3%	56.6%	34.9%
	Large (>250)	45.3%	43.4%	44.6%

Cars in household	0	0.8%	0.0%	0.5%
	1	27.5%	33.2%	29.5%
	2	58.9%	55.1%	57.6%
	3	9.2%	7.3%	8.5%
	> 4	3.7%	4.4%	3.9%
EV Experience	Not sure	11.3%	16.1%	12.9%
	No	6.3%	9.3%	7.3%
	Yes, seen	52.9%	35.6%	46.8%
	Yes, travelled	23.3%	28.8%	25.2%
	Yes, family has one	6.3%	10.2%	7.7%

3.3 Data analysis

The survey responses were entered in Excel and subsequently analysed with SPSS 25.0. In order to answer to what extent the sample is aware and knowledgeable about EVs, we use descriptive analyses of car ownership (ordinal); EV observation (nominal) – to differentiate between those children who have never even seen an EV and those who have; EV experience (nominal) – to differentiate between those children who state to have travelled in an EV; School Size (ordinal) and School Type (nominal) as proxies for socioeconomic status with smaller/public schools often situated in lower socioeconomic regions; Country (nominal) and School (nominal) as geographical proxies; favourite car (frequency as coded per car brand); the correctly answered responses to the question about car characteristics (nominal and grouped interval); and the car and EV purchase price estimations (interval).

The second question, how the sample perceives the benefits, disadvantages and future of personal cars is analysed through a two-step hierarchical cluster analysis on the ranking of the future expectations about personal cars. The cluster analysis is based on a Log-likelihood distance measure (due to the ordinal rank-order nature of the question on future car expectations) and Schwarz's Bayesian Criterion (BIC). After running various models while testing the outcome of 2 to 6 clusters, it was determined that 4 clusters (ratio of 1.75) offered the best identifiable and representable clusters. These groups then were labelled and used to analyse the other rank-order questions about the main benefits and downsides of cars.

Importantly, except for the cluster analysis and one regression involving age, the results below are analysed with nonparametric tests due to the non-random sample, the use of rank-order questions and a breach in normality for the independent variables used (statistically significant Kolmogorov-Smirnov tests).

4 Results and discussion

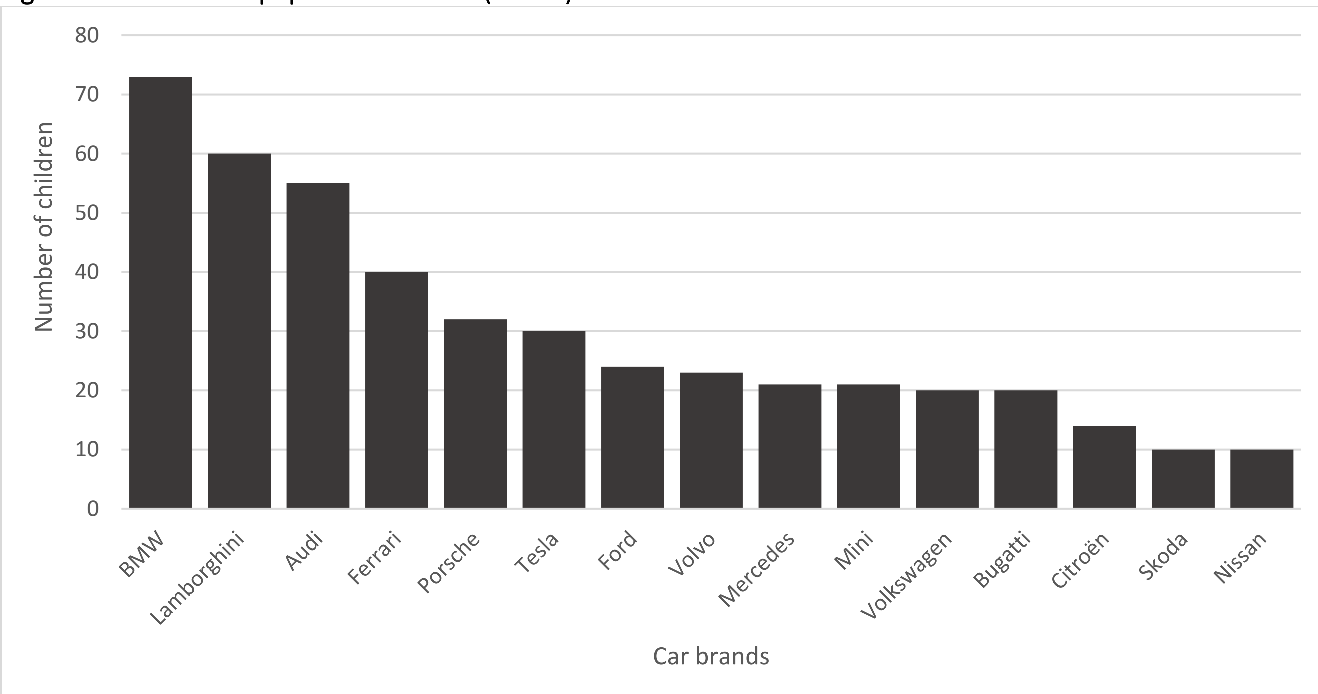
This section presents and analyses the results of the survey. Section 4.1 discusses the EV awareness and knowledge of the children, looking respectively at their favourite cars, the car characteristic questions and the cost-estimation questions. Section 4.2 then presents the results from the cluster analysis and reflects how these clusters relate to what the children ranked as the main advantages and disadvantages of personal cars.

4.1 Awareness and knowledge about EVs

To start, the sample offers a high car presence and popularity among our sample. Over 96.6% of the children confirm a desire to learn to drive, which is well above the 75% (Baslington, 2009) and 80% (Sigurdardottir et al., 2014) given by the literature. Our focus on less urbanized regions is further confirmed with an average mean household car ownership of 1.88 (SD = .86), with 99.5% of the children reporting to have at least one car in their household. Given the high presence of cars, the children had little trouble answering the question about their favourite car. After recoding the provided car models to their brand, sports cars ranked high and ranged from corvettes up to custom made Koenigsegg cars. However, the list was broad and included cars of all brands and types and even included one child's desire for a 'flying car'. The most popular brand was BMW (excluding Mini Coopers) with 12.4% of respondents, followed by Lamborghini (10.2%), Audi (9.4%), Ferrari (6.8%) and Porsche

(5.5%). Promising in relation to EV awareness is that 5.1% of the children (n=30) favoured a Tesla, making it the sixth most popular brand (see Figure 1).

Figure 1: The 15 most popular car brands (n=587)



Note: Figure 1 excludes 25 less frequently mentioned other brands (n=83), children who mentioned a type of vehicle instead of a model or brand, like a 4x4 (n=23), and inconclusive answers (n=28).

Continuing with electric cars, over 79% of the children state that they have seen or travelled in an EV before, while 7.3% have not and 12.8% do not know for sure. Of those answering positively, 25.2% state that they at one point have travelled in an EV and 7.7% say their parents own one. This latter seems skewed, as the general uptake of pluggable EVs in the Netherlands and Denmark is 1.38% and 0.44% of the respective car fleets (July 2017). Furthermore, these are regions with a lower socioeconomic status while EVs centre around large urban regions (IEA, 2017, p. 37). Besides indicating a skewed sample and potentially faulty answers, part of the difference between these percentages could be explained by the fact that we allowed for the inclusion of hybrids, which the total fleet shares above do not. While this implies that the answers below should be taken with care, the results do point to the presence of a sense of awareness and a level of insight about the electrification of private transport among the majority of our sample.

For example, in response to the question about which car characteristic (like acceleration, environmental impact and so on) corresponds best to either an EV or an ICEV, the schoolchildren answered 4.35 (SD = 1.01) of the six questions correctly. Keeping in mind an uncorrected 50% guess rate affecting the results, a little under 10% (55) answered all six correctly. The schoolchildren had no trouble identifying EVs as the most environmentally friendly (97.4% correct) and quieter car (93.4% correct). Simultaneously they seem to know about the range (71.2% correct) and charging time (82.8% correct) of an EV. They had trouble, however, with the cheaper costs per kilometre (51.6% correct) and the faster acceleration (38.3% correct) of an EV. Looking more closely, we observed, among others, a lack of *valid* Pearson Chi Square associations between the independent variables country, gender, school and EV experience and the question on the environmental characteristics of the cars, which might suggest that the environmental benefit of EVs is rather well-known among the children – independent of our measurements for nationality, gender, school or level of EV experience. Similarly, there are no associations for the question about the variable costs of driving, which indicates that this is less known across our sample or at least not related to our independent variables.

When it comes to the final ICEV vs EV score (adding up all correct answers), four independent variables stood out: EV experience, age, gender and school. Firstly, boys scored higher than girls. A Mann-Whitney U test indicates that the score was greater for boys (Mdn = 5; mean rank = 322.57) than for girls (Mdn = 4; mean rank = 265.13). This was statistically significant with U = 51,499.5 (Z = 4.333), p = < .001, but the difference between the boys and girls was small (r = .18). Secondly, in relation to level of EV experience, a Mann-Whitney U test indicates that those who have never even seen an EV (Mdn = 4; mean rank 238.19) score lower than those who have (Mdn = 5; mean rank 308.04). Again, the Mann-Whitney U value is significant, with U = 21085.5 (Z = -4.224), p < .001, and comes with a similar small effect (r = -.17). This lower score for those who have never seen an EV is confirmed with a

Mann-Whitney U test for actual EV travel experience, where those with experience (*Mdn* = 5; mean rank 312.88) score higher than those without experience (*Mdn* = 4; mean rank 284.75). This too was significant but comes with a lower significance level U = 41664 (z = 1.993), p = .046, and an even smaller effect (r = .08). Still it could indicate that passive observation and information provision already go a long way to support EV awareness and knowledge.

The final two variables that are noteworthy in relation to the ICEV vs EV score are age and geographical location (country and individual schools), primarily because of their lack of result. For instance, a simple linear regression to predict the score based on age found a significant regression (F (1,585) = 7.71, p = .006), but with an extremely small R^2 of .013 and a predicted score equal to 2.766 + .144 (age). So, although there is a significant relationship between age and the children's score, it is not as present as in some of the studies discussed in Section 2. Most likely, this is due to the survey design and our targeted focus on a specific age group.

Regarding the children's country of origin and their local schools, it is noteworthy that the children's score seems unrelated to either geographical proxy. Particularly, the latter is interesting as a Kruskal-Wallis test (H(14) = 19.510, p = .146) indicated that there was no significant variation between the individual schools and the mean final score of their children, thus indicating that the individual schools scored more or less equally, irrespective the presence of environmental or EV specific curricula (which we do not have data on).

Lastly, we studied the children's EV knowledge through two cost estimation questions. One on an ICEV and the other on an EV, in their national currency, to find if these children are aware that EVs currently are more expensive than ICEVs and to see whether the children's mean difference compares to a real-world difference. As expected, the answers to these questions have wide outliers from 0 to 100,000,000 euros. This partly results from the questions themselves, as it was up to the children what type of car they considered, but it is also influenced by the limited internalization of price experiences among children in our age groups (Damay et al., 2014).

Irrespective how we limit the outliers however, as a group the children seem to be aware of the higher price of an EV compared to an ICE vehicle – 88.2% of the children offers estimates whereby the EV is more expensive than the ICEV. Additionally, a Spearman's rank order correlation shows a reasonably but significant correlation between these two variables, $r_s\,(489) = .631$, $p < .001$, indicating that the children estimated EV prices structurally higher than ICEV prices across price levels. Furthermore, they come quite close to estimating the actual relative prices for an average car.

For instance, excluding the children with answers over 1,500,000 euros results in N=571 and a mean price of 35,996 euros for ICE vehicles (Median = 20,000 and *SD* = 73,253) and 78,040 euros for an EV (Median = 38,000 and *SD* = 149,718). These are already very valid mean estimates on their own, although clearly for cars in different market segments. With more stringent limits (excluding everything under 1000 euros and over 200,000 euros) we are left with N=489. A strong reduction, but one that results in the mean prices provided in Table 3 which clearly shows that Danish children, in line with higher car prices in their country, offer a higher estimate for both ICE vehicles and EVs, and that boys offer a slightly higher estimate for EVs. What's more, these results come close to the Dutch and Danish starting prices for a petrol Golf and the e-Golf (at the time of study, the Golf was the only car that came in both ICE, full electric and plug-in hybrid variants).

Table 3: Mean estimated ICE vehicle and EV prices (€)

		ICE			EV			Mean Price difference
	N	Mean	SD	Median	Mean	SD	Median	
Average	489	25,526	22,862	20,000	45,963	37,259	35,000	20,437
Dutch children	313	22,990	16,578	20,000	41,077	30,170	35,000	18,087
Danish children	176	30,035	30,586	20,134	54,652	46,149	40,268	24,617
Girls	232	25,008	24,455	20,000	44,320	39,335	35,000	19,312
Boys	257	25,993	21,359	20,134	47,446	35,292	35,000	21,453
Starting price for petrol Golf & e-Golf (July 2017)								
Netherlands		21,990			38,970			16,980
Denmark		27,206			40,668			13,462

In short, and taking into account the caveats of the survey design and the respondents, we find among our car dominant sample of schoolchildren several indications that they are both aware and to some extent knowledgeable about EVs. First, a subsection of children was able to bring up Tesla as their favourite car. Second, we found a minimum level of awareness about the differences between ICEVs and EVs. A closer look showed no variation in the mean of the total ICEV vs EV score across the countries or the schools, implying that with our questions and setting geography does not play a role. Instead we found in our sample that the girls, younger children and those who have never even seen an EV scored a bit lower than the boys and those pupils who have observed or travelled in an EV, but that all of these tests have a rather small effect on the final ICEV vs EV score. Lastly, the results indicate that even though the children have a wide variety of costs estimates, a majority offers a higher price estimate for EVs as compared to 'normal' cars. Furthermore, after the correction for extreme outliers their corrected means and medians come pretty close to actual market prices for a small size family car.

4.2 Perceptions on personal car use

Knowing that there is a certain level of awareness and knowledge about EVs among our sample of children leads us to the second question: how do they perceive modern day and the future of personal car-based transport? Three rank-order questions were used to answer this question: one about the main benefits of cars, one about the main disadvantages of cars and one about the future of personal car-based transport. This section will first present the results and composition of the cluster analysis on the future of personal car-based transport. It will then discuss how the clusters relate to the benefits and disadvantages of cars.

The results of the two-step cluster analysis can be found in Table 4 and Table 5. Briefly, and to give an indication of the relative importance attached to the rank-order questions, the average means have been added to both tables. These show that the children deem safety, freedom (go where you want) and aesthetics (looks and speed) the most important benefits of cars. In turn, the highest-ranking disadvantages were the danger that cars pose to vulnerable traffic participants and the car's environmental effects, only at a distance followed by things the children experience themselves (noise/smell and motion sickness). Lastly, children clearly ranked energy efficiency and safer cars highest among the future directions of car-based transport.

The cluster analysis of the answers to the rank-order question on the future of personal car-based transport offers four relative distinct and identifiable groupings. Summarized in Table 4, the cluster 'Vroom!' shows high rankings for more and larger cars and associated infrastructure. The cluster 'Car Free' has the highest mean ranks for less car-based transport, car free zones, and increased car purchase prices. The 'Alternative Fuels' cluster is the largest, and, true to its name, ranks a fuel shift as most important although it also comes with lower yet meaningful rankings of energy efficiency and increased safety. Lastly, the cluster 'Better Car' shows the highest mean rankings for the improvement of a car's energy efficiency and safety.

Table 4: Clusters with centroids based on future personal car expectations

	Total (n=587)	Vroom! 21.6% (n = 127)	Car Free 20.4% (n=120)	Alt. Fuels 35.8% (n=210)	Better Car 22.1% (n=130)
	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)	Mean (*SD*)
Drive less, more public transport	.31 (.78)	.09 (.32)	1.28 (1.24)	.03 (.18)	.08 (.28)
Increase energy efficiency	1.49 (1.21)	.75 (1.09)	.96 (1.10)	1.58 (1.15)	2.57 (.50)
More and larger cars	.48 (.94)	1.78 (1.20)	.12 (.39)	.12 (.37)	.12 (.32)
Fuel shift	1.16 (1.16)	.35 (.73)	.54 (.91)	2.44 (.50)	.43 (.50)
Safer cars	1.68 (1.12)	1.52 (1.20)	1.38 (1.21)	1.48 (1.11)	2.43 (.50)
More roads and parking	.35 (.76)	1.24 (1.12)	.03 (.18)	.13 (.38)	.12 (.33)
More car free zones	.39 (.80)	.15 (.44)	1.21 (1.26)	.19 (.43)	.19 (.40)
Make cars more expensive	.14 (.50)	.11 (.38)	.48 (.91)	.03 (.17)	.05 (.23)

Note: Means derived from 3 = first choice, 2 = second choice, 1 = last choice, 0 = not chosen. The grey accent highlights the highest mean among clusters.

Table 5 in turn illustrates the demographic composition of the clusters and how the cluster participants have answered the other two rank-order questions. The last column presents significant Chi-Square or Kruskal-Wallis results that indicate variance among the clusters and the respective variable. In this respect, Dutch schoolchildren are overrepresented in 'Vroom!' and 'Better Car' indicating that they are a bit more focused on current automobility practices then Danish children who more often chose the more drastic opportunities. Similarly, the boys are drastically overrepresented in the group 'Alternative Fuels', with consequential below average participation in the other clusters. The type and size of school shows no statistically significant variance. In contrast, those schoolchildren who have never seen an EV are overrepresented in the 'Car Free' cluster while those with travel experience in an EV are actually underrepresented in the 'Car Free' cluster, mainly because of their overrepresentation in the 'Alternative Fuels' cluster fitting an EV focus.

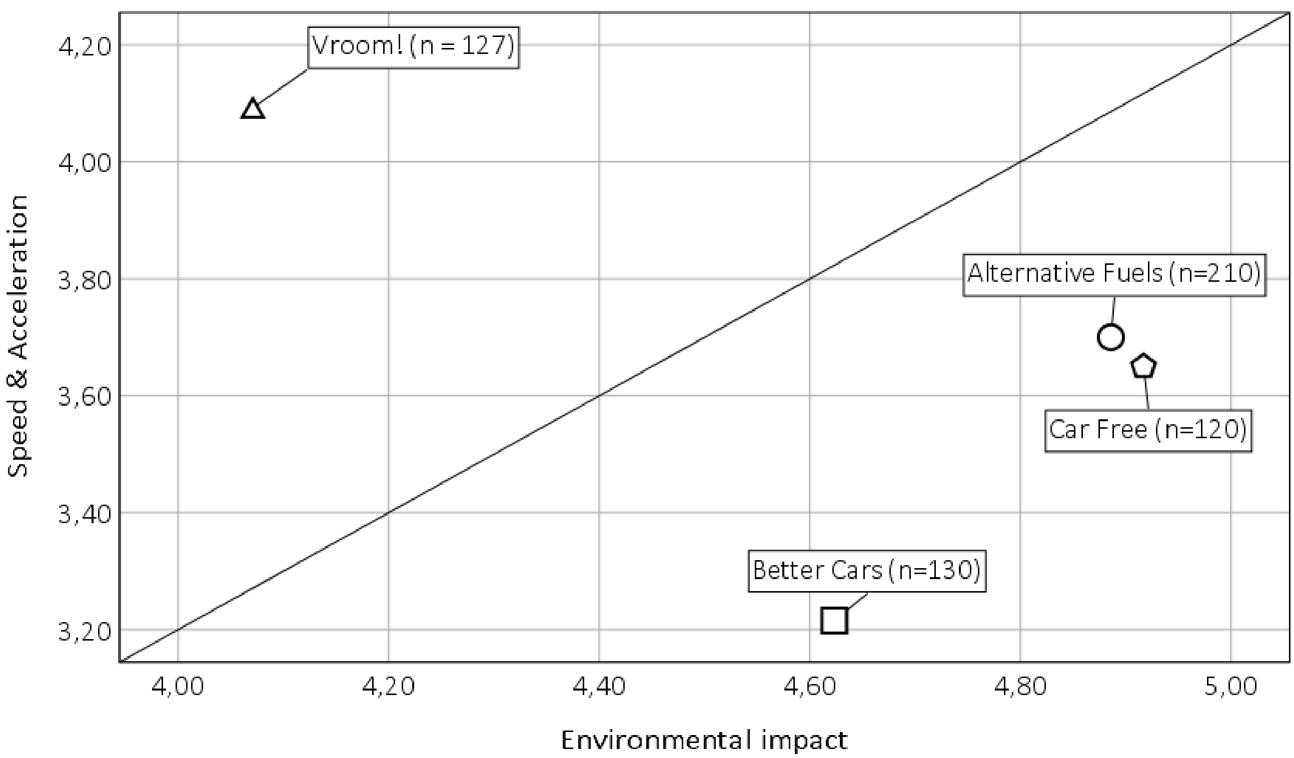
Table 5: Illustrative analysis of clusters

	Total (n=587)	Vroom! 21.6% (n = 127)	Car Free 20.4% (n=120)	Alt. Fuels 35.8% (n=210)	Better Car 22.1% (n=130)	
Demographics [a]						
Netherlands	65.1%	70.1%	56.7%	58.6%	78.5%	$\chi^2(3) = 19.29$***
Denmark	34.9%	29.9%	43.3%	41.4%	21.5%	
Girl	49.7%	54.3%	56.7%	38.6%	56.9%	$\chi^2(3) = 16.54$**
Boy	50.3%	45.7%	43.3%	61.4%	43.1%	
Small Schools (0 to 125)	20.4%	16.5%	23.3%	19.5%	23.1%	
Medium Schools (126 to 250)	34.9%	29.9%	41.7%	36.7%	30.8%	
Large Schools (>250)	44.6%	53.5%	35.0%	43.8%	46.2%	
Public school	30.2%	25.2%	32.5%	27.6%	36.9%	
Charter school	69.8%	74.8%	67.5%	72.4%	63.1%	
No visual EV observation	20.3%	16.5%	30.8%	18.1%	17.7%	$\chi^2(3) = 10.53$*
Travel experience in EV	32.9%	31.5%	22.5%	39.0%	33.8%	$\chi^2(3) = 9.64$*
Demographics [b]						
Age	10.96 (.80)	10.87 (.75)	10.93 (.85)	10.98 (.79)	11.05 (.82)	
Nr. of cars household	1.88 (.86)	1.91 (1.03)	1.79 (.77)	1.93 (.83)	1.86 (.80)	
ICEV vs EV score	4.35 (1.01)	4.35 (.99)	4.27 (1.09)	4.41 (1.04)	4.32 (.92)	
Benefits of cars [b]						
4A: Nice looking	3.7 (1.57)	4.05 (1.53)	3.75 (1.64)	3.68 (1.56)	3.35 (1.49)	H(3) = 13.42**
4B: Can go fast	3.67 (1.54)	4.09 (1.44)	3.65 (1.56)	3.70 (1.61)	3.22 (1.36)	H(3) = 20.25***
4C: Go where you want	4.19 (1.36)	3.94 (1.41)	4.27 (1.38)	4.18 (1.38)	4.38 (1.25)	
4D: Feels like home	2.86 (1.42)	2.91 (1.37)	2.82 (1.46)	2.78 (1.43)	2.98 (1.43)	
4E: Safe	4.62 (1.59)	4.36 (1.58)	4.36 (1.70)	4.62 (1.52)	5.12 (1.49)	H(3) = 24.43***
4F: Silent	1.96 (1.30)	1.65 (1.20)	2.16 (1.38)	2.04 (1.34)	1.97 (1.24)	H(3) = 15.17**
Disadvantages of cars [b]						
5A: Dangerous	4.56 (1.53)	4.18 (1.82)	4.76 (1.46)	4.57 (1.40)	4.73 (1.45)	
5B: Noise and Smell	3.22 (1.48)	3.07 (1.50)	3.18 (1.50)	3.34 (1.47)	3.22 (1.45)	
5C: Takes lots of Space	2.64 (1.41)	2.94 (1.49)	2.62 (1.32)	2.58 (1.40)	2.48 (1.41)	
5D: Env. impact	4.66 (1.42)	4.07 (1.54)	4.92 (1.25)	4.89 (1.33)	4.62 (1.41)	H(3) = 30.73***
5E: Motion sickness	3.23 (1.52)	3.65 (1.63)	3.09 (1.41)	3.12 (1.50)	3.11 (1.47)	H(3) = 11.24*
5F: Showing off	2.70 (1.64)	3.06 (1.81)	2.44 (1.48)	2.54 (1.56)	2.83 (1.67)	H(3) = 8.95*

Note: * $p < .05$, ** $p < .01$, *** $p < .001$. The grey accent highlights the highest mean among clusters.
[a] Column %; analysed with Pearson Chi-Square test of independence.
[b] Mean (SD); analysed with Kruskal-Wallis H test of similar mean ranks across clusters.

The distinct nature of the clusters on the future of car-based transport dissipates slightly when reflecting on the other rank-order questions. On the one hand, the 'Vroom!' cluster in line with its future orientation, ranks the aesthetics of vehicles highest among the clusters, and, not surprisingly, it ranks the environmental impact significantly lower than the ‘Car Free’ cluster (see also Figure 2). Counterintuitive to the focus on aesthetics, these participants also rank showing off as a relatively important disadvantage of cars. This could potentially indicate a lack of understanding of the question or it could highlight a dual position towards the aesthetics of a car – that having and enjoying a nice and fast car is different from purposefully parading it as such? The ‘Car Free’ cluster, in line with its focus, finds silence important, just as they rank the danger of cars to other traffic participants and the environmental impact of cars as important disadvantages. The ‘Alternative Fuel’ cluster does not have specific benefits or disadvantages, except for a slight overrepresentation of noise and smell as a disadvantage, which fits with a choice for electrification of transport. Lastly, the schoolchildren making up ‘Better Cars’ average out on the disadvantages of a car but did rank freedom (Rajan, 2006), the home-like experience (e.g. cocooning (Lupton, 1999)) and safety as important benefits of a car; again supporting the corresponding future orientation towards a better car.

Figure 2: The cluster’s mean for car characteristics 'Speed & Acceleration' vs 'Environmental Impact' (n=587)



Note: Mean of rank-order questions with 1 = lowest ranked and 6 = highest ranked.

All in all, these illustrative variables seem to confirm the underlying motivations of the clusters. The clusters thus seem to highlight different sets of perceptions about current and future car use among groups of (car biased) children. These perceptions seem, at least in our sample, primarily motivated by gender, nationality, EV experience and factors outside our survey, rather than the size and type of school. That said, a Pearson Chi-Square test indicates that the individual schools do show a wide variance in cluster membership, see Appendix B, with $\chi^2(42) = 77.71$, $p < .001$. Location, gender and awareness thus all matter. More generally however, and keeping in mind the car-based focus behind this survey as well as the rural and intermediate geography, most of the children see a transformation and improvement of cars instead of a future with less car-based transport. That gives both cause for concern and hope: on the one hand, and given the confines of the survey design, the imagination of children is not as boundless as the cliché makes it be (with the exception of the one flying car), yet simultaneously only a 21.6% minority of the children espouses a desire for traditional automobility.

5 Conclusion

This paper asked two questions. It asked whether modern-day children in the Netherlands and Denmark are aware and knowledgeable about electric vehicles? It also asked how these children perceive the benefits, disadvantages and future of personal cars? Based on the results of the survey, we find that the children in our sample are quite aware and knowledgeable about EVs. Not only that, the means show that they rank the environmental impacts of cars higher than the internal and external safety aspects of cars and well ahead of other disadvantages and future policy directions. Of course, not all the children in our sample think so, as given by the four clusters of answers to the future of car-based transport.

First, the results show that children have a basic level of awareness and knowledge about electric vehicles. One indication for this is the popularity of a certain already named electric car brand, but more specifically the children in our sample are aware of the environmental benefits and noise reduction of EVs, although fewer know about the shorter range and charging time, and even less know about the variable costs and acceleration. A majority of the children also correctly estimated a higher price for EVs, which seems to indicate that they are aware of the real-world price difference. In fact, as a group they came close to the actual price of the EV and ICEV version of a small sized family car. Lastly, the ICEV vs EV score showed significant variation for gender, age and EV exposure as the girls, younger children and those who have never seen an EV in our sample scored lower than their counterparts. In line with the current EV uptake discussion, to us this implies that a further dispersion of electric vehicles would benefit from opportunities to test drive or travel in an EV so that people can experience and see the fun of driving in these cars. However, the fact that those children who have at some point in their life seen an EV already score better indicates that information campaigns and advertisements may come a long way as well.

Figure 3: The clusters' mean across the advantages and disadvantages of cars (n=587)

Note: Mean of rank-order questions with 1 = lowest ranked and 6 = highest ranked

Second, a cluster analysis of the schoolchildren's ranking of the future of personal cars offered four readily identifiable clusters: 'Vroom!' (traditional flashy automobility), 'Car Free' (less driving, car free zones, etc), 'Alternative Fuels' (technical shift away from fossil fuels) and 'Better Cars' (more efficient and safer vehicles). The underlying positions of these clusters were then confirmed through the corresponding importance of relevant questions about the benefits and disadvantages of cars (as summarized in Figure 3). The clusters furthermore had different membership patterns by gender, geography and EV exposure. The Dutch schoolchildren were overrepresented in the more traditional car options 'Vroom!' and 'Better Car', just as the boys and those with EV exposure were overrepresented in the 'Alternative Fuels' cluster, and the children without EV exposure were overrepresented in the 'Car Free' cluster.

Taking a step back and keeping in mind the car-based focus behind this survey as well as the rural and intermediate geography, with 21.4% of the sample favouring traditional car attributes and another 20.4% favouring car alternatives or disincentives, we find 55.9% of the children to favour a technical transformation and/or improvement of cars. Whether this is a hopeful or troubling conclusion depends on one's perspective. From a transition perspective, we could argue that threequarters of our sample accepts the environmental consequences and the need to improve, shift and reduce car-based transport. From a sustainable mobility perspective however, an alternative and more depressing conclusion could be that threequarters of our sample still uphold the sociotechnical system of automobility with all its negative environmental (Sims et al., 2014), social (Urry, 2004), health (Chambliss et al., 2014) and animal welfare (Desmond, 2013) consequences.

While more research might not fully resolve this interpretative conundrum, the survey's results do offer plenty of opportunity and justification for future work on a wider selection of children in different (national) contexts, and with a more extensive and structural approach to measuring the children's attitudes and EV knowledge. For example, even though the survey confirms that there are local and national differences between the children, it is unclear how these geographical levels relate and where the differences stem from, whether they are related to geography, curriculum, media influences, cultural differences or can be derived from parents and teachers (and their socioeconomic status, education, environmental concerns, and so on). Furthermore, a more longitudinal study into the stability of the children's car preferences and attitudes would be of interest, especially if taken in combination with environmental attitudes. Likewise, in line with our argument that children could act as proxies for uninterested adults and noting that children are highly impressionable and often explicit targets of environmental campaigns and curricula, more attention to international studies on the environmental and transport awareness of children and other non-primary consumer groups, like senior citizens and disabled people, is in order, as well as subsequent comparisons to studies focusing on car buyers.

All in all, we find the results from the survey promising instead of disheartening. The children seem aware of the environmental impact of transportation and the need to move away from ICE vehicles. Unfortunately, it will take another decade or two before these children's still developing mobility preferences actually become cemented into consumption patterns when they start to exert their preferences on the car and mobility markets. In other words, their car preferences are important for the 2050 climate targets but not yet a factor for the targets of 2030, and their knowledge and preferences could change well before then. Thus, while children may indeed be the adult adopters of low-carbon mobility options of the future, they still need strong policies and adult role models to enable, motivate, and guide them to reduce global emissions as fast as possible.

6 Literature cited

Axsen, J., Goldberg, S., Bailey, J., 2016. How might potential future plug-in electric vehicle buyers differ from current "Pioneer" owners? Transportation Research Part D: Transport and Environment 47, 357–370. https://doi.org/10.1016/j.trd.2016.05.015

Axsen, J., Orlebar, C., Skippon, S., 2013. Social influence and consumer preference formation for pro-environmental technology: The case of a U.K. workplace electric-vehicle study. Ecological Economics 95, 96–107. https://doi.org/10.1016/j.ecolecon.2013.08.009

Axsen, J., Sovacool, B.K., 2019. The roles of users in electric, shared and automated mobility transitions. Transportation Research Part D: Transport and Environment. https://doi.org/10.1016/j.trd.2019.02.012

Bailey, J., Axsen, J., 2015. Anticipating PEV buyers' acceptance of utility controlled charging. Transportation Research Part A: Policy and Practice 82, 29–46. https://doi.org/10.1016/j.tra.2015.09.004

Balmford, A., Clegg, L., Coulson, T., Taylor, J., 2002. Why Conservationists Should Heed Pokémon. Science 295, 2367–2367. https://doi.org/10.1126/science.295.5564.2367b

Baslington, H., 2009. Children's perceptions of and attitudes towards, transport modes: why a vehicle for change is long overdue. Children's Geographies 7, 305–322. https://doi.org/10.1080/14733280903024472

Batterham, D., Stanisstreet, M., Boyes, E., 1996. Kids, cars and conservation: children's ideas about the environmental impact of motor vehicles. International Journal of Science Education 18, 347–354. https://doi.org/10.1080/0950069960180307

Bell, A., 2007. Designing and testing questionnaires for children. Journal of Research in Nursing 12, 461–469. https://doi.org/10.1177/1744987107079616

Borg, F., Winberg, T.M., Vinterek, M., 2017. Preschool children's knowledge about the environmental impact of various modes of transport. Early Child Development and Care 0, 1–16. https://doi.org/10.1080/03004430.2017.1324433

Borgers, N., Hox, J., Sikkel, D., 2003. Response Quality in Survey Research with Children and Adolescents: The Effect of Labeled Response Options and Vague Quantifiers. International Journal of Public Opinion Research 15, 83–94. https://doi.org/10.1093/ijpor/15.1.83

Boyes, E., Stanisstreet, M., 1998. Children's ideas about cars and health: an environmental motivator? Transportation Research Part D: Transport and Environment 3, 105–115. https://doi.org/10.1016/S1361-9209(97)00031-X

Boyes, E., Stanisstreet, M., 1997. The Environmental Impact of Cars: children's ideas and reasoning. Environmental Education Research 3, 269–282. https://doi.org/10.1080/1350462970030302

Buekers, J., Van Holderbeke, M., Bierkens, J., Int Panis, L., 2014. Health and environmental benefits related to electric vehicle introduction in EU countries. Transportation Research Part D: Transport and Environment 33, 26–38. https://doi.org/10.1016/j.trd.2014.09.002

Chambliss, S.E., Silva, R., West, J.J., Zeinali, M., Minjares, R., 2014. Estimating source-attributable health impacts of ambient fine particulate matter exposure: global premature mortality from surface transportation emissions in 2005. Environmental Research Letters 9, 104009. https://doi.org/10.1088/1748-9326/9/10/104009

Damay, C., Guichard, N., Clauzel, A., 2014. Children's price knowledge. Young Consumers 15, 167–177. https://doi.org/10.1108/YC-06-2013-00374

Davison, Paul, Davison, Phillippa, Reed, N., Halden, D., Dillon, J., 2003. Children's Attitudes to Sustainable Transport (No. 174/2003), Transport Research Series. Scottish Executive Social Research.

Desmond, J., 2013. Requiem for Roadkill: Death and Denial on America's Roads, in: Kopnina, H., Shoreman-Ouimet, E. (Eds.), Environmental Anthropology: Future Directions. Routledge, New York and London, pp. 46–58.

Easton, S., Ferrari, E., 2015. Children's travel to school—the interaction of individual, neighbourhood and school factors. Transport Policy 44, 9–18. https://doi.org/10.1016/j.tranpol.2015.05.023

Egbue, O., Long, S., 2012. Barriers to widespread adoption of electric vehicles: An analysis of consumer attitudes and perceptions. Energy Policy, Special Section: Frontiers of Sustainability 48, 717–729. https://doi.org/10.1016/j.enpol.2012.06.009

Egbue, O., Long, S., Ng, E.-H., 2015. Charge It! Translating Electric Vehicle Research Results to Engage 7th and 8th Grade Girls. J Sci Educ Technol 24, 663–670. https://doi.org/10.1007/s10956-015-9555-7

EUROSTAT, 2017. NUTS 2 regional statistics.

Figueres, C., Schellnhuber, H.J., Whiteman, G., Rockström, J., Hobley, A., Rahmstorf, S., 2017. Three years to safeguard our climate. Nature News 546, 593. https://doi.org/10.1038/546593a

Geels, F.W., Sovacool, B.K., Schwanen, T., Sorrell, S., 2017. Sociotechnical transitions for deep decarbonization. Science 357, 1242–1244. https://doi.org/10.1126/science.aao3760

Graham-Rowe, E., Gardner, B., Abraham, C., Skippon, S., Dittmar, H., Hutchins, R., Stannard, J., 2012. Mainstream consumers driving plug-in battery-electric and plug-in hybrid electric cars: A qualitative analysis of responses and evaluations. Transportation Research Part A: Policy and Practice 46, 140–153. https://doi.org/10.1016/j.tra.2011.09.008

Greening, L.A., Greene, D.L., Difiglio, C., 2000. Energy efficiency and consumption — the rebound effect — a survey. Energy Policy 28, 389–401. https://doi.org/10.1016/S0301-4215(00)00021-5

Helbich, M., Emmichoven, M.J.Z. van, Dijst, M.J., Kwan, M.-P., Pierik, F.H., Vries, S.I. de, 2016. Natural and built environmental exposures on children's active school travel: A Dutch global positioning system-based cross-sectional study. Health & Place 39, 101–109. https://doi.org/10.1016/j.healthplace.2016.03.003

IEA, 2017. Global EV Outlook 2017. OECD / International Energy Agency, Paris.

IEA, 2015. Energy and Climate Change: World Energy Outlook Special Report. OECD / International Energy Agency, Paris.

IRENA, 2018. Global Energy Transformation: A Roadmap to 2050. International Renewable Energy Agency, Abu Dhabi.

Isenhour, C., 2010. On conflicted Swedish consumers, the effort to stop shopping and neoliberal environmental governance. Journal of Consumer Behaviour 9, 454–469. https://doi.org/10.1002/cb.336

Jacobson, M.Z., 2009. Review of solutions to global warming, air pollution, and energy security. Energy Environ. Sci. 2, 148–173. https://doi.org/10.1039/B809990C

Kaplan, S., Nielsen, T.A.S., Prato, C.G., 2016. Walking, cycling and the urban form: A Heckman selection model of active travel mode and distance by young adolescents. Transportation Research Part D: Transport and Environment 44, 55–65. https://doi.org/10.1016/j.trd.2016.02.011

Kester, J., Noel, L., Zarazua de Rubens, G., Sovacool, B.K., 2018. Policy mechanisms to accelerate electric vehicle adoption: A qualitative review from the Nordic region. Renewable and Sustainable Energy Reviews 94, 719–731. https://doi.org/10.1016/j.rser.2018.05.067

Kopnina, H., 2011. Kids and cars: Environmental attitudes in children. Transport Policy 18, 573–578. https://doi.org/10.1016/j.tranpol.2011.01.013

Kopnina, H., Williams, M., 2012. Car attitudes in children from different socio-economic backgrounds in the Netherlands. Transport Policy 24, 118–125. https://doi.org/10.1016/j.tranpol.2012.07.010

Langbroek, J.H.M., Franklin, J.P., Susilo, Y.O., 2018. How would you change your travel patterns if you used an electric vehicle? A stated adaptation approach. Travel Behaviour and Society 13, 144–154. https://doi.org/10.1016/j.tbs.2018.08.001

Leeson, E., Stanisstreet, M., Boyes, E., 1997a. Children's ideas about the environmental impact of cars: a cross age study. International Journal of Environmental Studies 52, 89–103. https://doi.org/10.1080/00207239708711098

Leeson, E., Stanisstreet, M., Boyes, E., 1997b. Primary children's ideas about cars and the environment. Education 3-13 25, 25–29. https://doi.org/10.1080/03004279785200201

Liao, F., Molin, E., Wee, B. van, 2017. Consumer preferences for electric vehicles: a literature review. Transport Reviews 37, 252–275. https://doi.org/10.1080/01441647.2016.1230794

Line, T., Chatterjee, K., Lyons, G., 2012. Applying behavioural theories to studying the influence of climate change on young people's future travel intentions. Transportation Research Part D: Transport and Environment 17, 270–276. https://doi.org/10.1016/j.trd.2011.12.004

Line, T., Chatterjee, K., Lyons, G., 2010. The travel behaviour intentions of young people in the context of climate change. Journal of Transport Geography 18, 238–246. https://doi.org/10.1016/j.jtrangeo.2009.05.001

Lupton, D., 1999. Monsters in metal cocoons: "Road rage" and cyborg bodies. Body & Society 5, 57–72.

Mitra, R., Buliung, R.N., 2015. Exploring differences in school travel mode choice behaviour between children and youth. Transport Policy 42, 4–11. https://doi.org/10.1016/j.tranpol.2015.04.005

Pacala, S., Socolow, R., 2004. Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. Science 305, 968–972. https://doi.org/10.1126/science.1100103

Payne, P.G., 2016. The politics of environmental education. Critical inquiry and education for sustainable development. The Journal of Environmental Education 47, 69–76. https://doi.org/10.1080/00958964.2015.1127200

Rajan, S.C., 2006. Automobility and the liberal disposition. The Sociological Review 54, 113–129. https://doi.org/10.1111/j.1467-954X.2006.00640.x

Rezvani, Z., Jansson, J., Bodin, J., 2015. Advances in consumer electric vehicle adoption research: A review and research agenda. Transportation Research Part D: Transport and Environment 34, 122–136. https://doi.org/10.1016/j.trd.2014.10.010

Ryghaug, M., Toftaker, M., 2014. A Transformative Practice? Meaning, Competence, and Material Aspects of Driving Electric Cars in Norway. Nature and Culture 9. https://doi.org/10.3167/nc.2014.090203

Seebauer, S., 2018. The psychology of rebound effects: Explaining energy efficiency rebound behaviours with electric vehicles and building insulation in Austria. Energy Research & Social Science 46, 311–320. https://doi.org/10.1016/j.erss.2018.08.006

Sigurdardottir, S.B., Kaplan, S., Møller, M., 2014. The motivation underlying adolescents' intended time-frame for driving licensure and car ownership: A socio-ecological approach. Transport Policy 36, 19–25. https://doi.org/10.1016/j.tranpol.2014.07.001

Sims, R., Schaeffer, R., Creutzig, F., Cruz-Nunez, X., D'Agosto, M., Dimitriu, D., figueroa Meza, M.J., Fulton, L., Kobayashi, S., Lah, O., McKinnon, A., Newman, P., Ouyang, M., Schauer, .J., Sperling, D., Tiwari, G., 2014. Transport, in: Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Farahani, E., Kadner, S., Seyboth, K., Adler, A., Baum, I., Brunner, S., Eickemeier, P., Kriemann, B., Savolainen, J., Schlömer, ., von Stechow, C., Zwickel, T., Minx, J.C. (Eds.), Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovern-Mental Panel on Climate Change. Cambridge University Press, Cambridge and New York.

Sioshansi, R., Denholm, P., 2009. Emissions Impacts and Benefits of Plug-In Hybrid Electric Vehicles and Vehicle-to-Grid Services. Environmental Science & Technology 43, 1199–1204. https://doi.org/10.1021/es802324j

Sovacool, B.K., Axsen, J., Kempton, W., 2017. Tempering the Promise of Electric Mobility? A Sociotechnical Review and Research Agenda for Vehicle-Grid Integration (VGI) and Vehicle-to-Grid (V2G). Annual Review of Environment and Resources 42. https://doi.org/10.1146/annurev-environ-030117-020220

Sovacool, B.K., Hirsh, R.F., 2009. Beyond batteries: An examination of the benefits and barriers to plug-in hybrid electric vehicles (PHEVs) and a vehicle-to-grid (V2G) transition. Energy Policy 37, 1095–1103. https://doi.org/10.1016/j.enpol.2008.10.005

Sovacool, B.K., Kester, J., Heida, V., 2019. Cars and kids: Childhood perceptions of electric vehicles and sustainable transport in Denmark and the Netherlands. Technological Forecasting and Social Change 144, 182–192. https://doi.org/10.1016/j.techfore.2019.04.006

Urry, J., 2004. The “System” of Automobility. Theory, Culture & Society 21, 25–39. https://doi.org/10.1177/0263276404046059

Williams, J.H., DeBenedictis, A., Ghanadan, R., Mahone, A., Moore, J., Morrow, W.R., Price, S., Torn, M.S., 2012. The Technology Path to Deep Greenhouse Gas Emissions Cuts by 2050: The Pivotal Role of Electricity. Science 335, 53–59. https://doi.org/10.1126/science.1208365

7 Appendix A: Survey

Please mark the appropriate box next to your answer with an "x". Answer all of the questions to the best of your ability. I am here if you have a question yourself!

1. What is your favourite car? ....

2. Would you like to learn to drive when you grow up?
   - ☐ Yes
   - ☐ No
   - ☐ Maybe

3. Do your parents have a car at home? ☐ Yes ☐ No
   a. If yes, how many? ....
   b. If not, how do you travel? ....
   ....

4. What is most important about a car? Rank them 1 to 6, number 1 is what you find most important.

a. That cars look nice	
b. That cars can go fast	
c. That cars can go wherever you want	
d. That cars feel like home	
e. That cars are safe	
f. That cars are silent	

5. What is the most important downside of cars? Rank them 1 to 6, number 1 is what you like least!

a. That cars are dangerous (for people and animals)	
b. That cars are noisy and smelly	
c. That cars take a lot of space for parking and driving	
d. That cars are bad for the environment	
e. That people can become sick in a car (motion sickness)	
f. People tend to show off with cars (status symbol)	

6. How much do you think that a normal car costs? ....

7. Have you ever seen or travelled in an electric car?
   - ☐ No
   - ☐ Yes, I have seen them
   - ☐ Yes, I have travelled in one
   - ☐ Yes, my parents own one
   - ☐ Not sure
   - ☐

8. Which car …
   Choose one by marking the box.

	Petrol or diesel car	Electrical car
a. … is best for the environment?		
b. … accelerates faster		
c. … makes the least amount of noise?		
d. … has the longest range?		
e. … is cheaper to drive?		
f. … is quickest to fill after it is empty?		

9. How much do you think that an electric car costs? ....

10. In the future, we should …
    Select your top 3. number 1 is your first choice.

a. Drive less and take more public transport	
b. Make cars more energy efficient	
c. Build more and larger cars	
d. Shift cars to other fuels	
e. Build safer cars to survive accidents	
f. Build more roads and parking space	
g. Make more areas prohibited for cars	
h. Make cars more expensive	
i. It is not on the list, but we should:	

I am a girl / boy and I am …….. years old.

8 Appendix B: Location of schools and their cluster membership

Country	Region	Place	Vroom! 21.6% (n = 127)	Car Free 20.4% (n=120)	Alt. Fuels 35.8% (n=210)	Better Car 22.1% (n=130)
Netherlands	Friesland	Oosterwolde	3.7%	22.2%	40.7%	33.3%
	Friesland	Donkerbroek	24.0%	20.0%	32.0%	24.0%
	Friesland	Noordwolde	29.4%	17.6%	17.6%	35.3%
	Overijssel	Dedemsvaart	29.6%	12.7%	26.8%	31.0%
	Friesland	Boijl	23.8%	19.0%	38.1%	19.0%
	Flevoland	Lelystad	30.4%	12.7%	32.4%	24.5%
	Friesland	Wolvega 1	7.7%	38.5%	23.1%	30.8%
	Friesland	Wolvega 2	15.0%	15.0%	55.0%	15.0%
	Friesland	Beetsterzwaag	0.0%	27.3%	45.5%	27.3%
	Friesland	Langezwaag	44.8%	13.8%	24.1%	17.2%
	Friesland	Oldeberkoop	6.1%	24.2%	36.4%	33.3%
Denmark	Midtjylland	Herning 1	22.0%	17.1%	43.9%	17.1%
	Midtjylland	Holstebro	9.1%	33.3%	36.4%	21.2%
	Midtjylland	Silkeborg	18.0%	22.5%	44.9%	14.6%
	Midtjylland	Herning 2	23.8%	33.3%	40.5%	2.4%